Revista de Análisis Económico, Vol. 3, Nº 2, pp. 207-228 (Noviembre 1988)

INFORMATIONAL ASYMMETRIES AND THE INTERNATIONAL TRANSMISSION OF BUSINESS CYCLES

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Abstract:

Several recent papers have analyzed the international transmission of economic disturbances in a context in wich all goods are traded. Additionally, those papers assume alternatively full contemporaneous information on financial variables is not available at all. A key feature of the model is that agents in each country observe all those variables directly linked with the markets in wich they usually trade but they do not have access to the information provided by the market for nontraded goods in the foreign country. Therefore, the introduction of nontreded goods provides a natural setting for assuming an asymmetry in the information set available to agents across countries. It is shown that this asymmetry is crucial for the existence of real effects associated with monetary shocks and also for the nature of the international transmission of business cycles across countries.

1. Introduction

With the collapse of the Bretton Wood system in 1973, countries were free to float their currencies or to adopt regional pegged currency schemes, that floated against the dollar. As a result of this experience, research and new evidence about the behavior of flexible rate systems have rapidly accumulated, causing a radical change that affected the traditional views associated with the properties of floating rates.

During the 1960s, the prevalent view was that flexible rates could insulate a country from external disturbances and thereby, could provide more autonomy for the formulation of stabilization policies. Four channels of interdependence were often discussed in

* Many thanks to an anonymous referee of this journal. Any remaining errors are my own, however.

the literature on international transmission: (1) the Balance of Payments, (2) Goods substitution, (3) Bonds substitution and (4) the Terms of Trade. It was assumed that under fixed rates all of those channels could eventually work, whereas under flexible rates some of these channels could be blocked[1]. With respect to the importance of the channels of transmission, the current empirical literature presents mixed results. In Darby *et al.* (1984), the channels were found to be surprisingly weak, suggesting that the independce of monetary policies under a fixed exchange rate regime is not substantially affected. On the other hand, Choudri and Kochin (1980) present evidence showing that flexible rates could provide a substantial insulation against foreign shocks. The experience, however, with flexible rates after the breakdown of the Bretton Wood system, suggests that international interdependence has not been eliminated, but instead, has increased since 1973. Moreover, much of the evidence from this period, conflicts with the predictions of conventional exchange rate theories: exchange rates have not simply adjusted to offset inflation rate differentials across countries and the degree of synchronization in fluctuations in employment, prices and so on has increased[2].

The degree of synchronization in economic fluctuations across countries has been discussed at length in the literature. Typically, the international transmission process has been examined in the context of models in which the supply side of the economy is assumed to be passive and output is determined by the demand side. Keynesian models (see Mundell (1968) and Dornbusch and Krugman (1976)) suggest that the key factor in the transmission mechanism is the interaction between the rate of interest and the exchange rate. For example, Mundell has shown that with capital mobility, an expansionary fiscal policy is transmitted positively to the rest of the world, whereas an expansionary monetary policy is transmitted negatively[3]. The mechanism of transmission in these types of models depends crucially on the assumption that there is a one-to-one correspondence between movements in the exchange rate and movements in the terms of trade. Of course, this is an implication of conventional Keynesian models in which prices are predetermined. More recently, the framework of analysis has changed from deterministic Keynesian models in which output is demand determined, to stochastic models in which the supply side is explicitly introduced. While in both of these models, monetary disturbances can have real effects, they have different implications for the behavior of some key macrovariables during the process of adjustment. In particular, equilibrium models imply that home and foreign output respond to monetary shocks, in general, in a symmetric manner and only in exceptional cases will domestic and foreign output move in opposite directions[4].

The sequence of worldwide recessions after the collapse of Bretton Wood and the loss of credibility of both Keynesian and monetarist models have stimulated the appearance of new explanations about the nature of business cycles. A common feature of most of these new theories is the attempt to reconcile business cycles with the basic principles of the competitive general equilibrium theory: continuous clearing of all markets and consistent pursuit of self-interest by individuals.

The main difference among these theories is related with the relative importance attributed to real and monetary factors. Misperception models emphasize the role of monetary shocks in the propagation of business cycles. Random monetary shocks induce price misperceptions which induce wrong production decisions. On the other hand, "real business cycles" models emphasize the role of variables such as tasted and tecnology as the main determinants of business fluctuations (see Long and Plosser (1983), King and Plosser (1984) and Singleton and Eichenbaum (1986)). Here the basic idea is that unanticipated changes in tastes and/or technology cause intersectoral movements of

resources which penalize some sectors and benefit others. These transfer of resources, it is argued, may have significant effects on aggregate employment if there are important costs of adjustment associated with a rapid transfer of resources. However these types of models can hardly explain the recurrent sequences of expansions and contractions that characterize business fluctuations in the real world. Real shocks alone may eventually explain temporal fluctuations of economic variables but they are inconsistent with persistent fluctuations of real variables in an economy with market clearing. Probably this is also true for misperception models, but at least, monetary theories of business fluctuations, whether the "incomplete information" type or the "sticky price" type, attempt to rationalize the behavior of institutions which obviously play an important role in the way business fluctuations are propagated[5]. "Real business cycles" theories, on the other hand, tend to abstract from money and government, assuming either complete endogeneity of money or alternatively complete neutrality of the traditional instruments of economic policies[6]. There is little evidence to support these extreme assumptions.

In spite of the explosion of literature dealing with business cycles and international transmission, this literature, however, focuses almost exclusively on the use of one commodity models. In addition, when the foreign sector is explicitly analyzed, this is made, in general within the context of small open economies in which the underlying sources of fluctuations are not analyzed. However, most of the disturbances experienced by the world economy during the last decade were transmitted, primarily through movements in relative prices and were associated with significant transfers of resources across sectors. On the other hand the increased interdependence in the world economy suggests that the discussion of business cycles should be made within the context of models in which feedback effects across countries are explicitly considered.

The purpose of this paper is to develop a model suitable for the analysis of the international transmission of business cycles and its effects upon the process of resource allocation. The issue here is not only whether disturbances in one country are transmitted positively or negatively to another country in terms of the aggregate level of employment but more important is related with the effects upon the economic structure and the allocation of resources across sectors.

The basic model is an open economy version of the type of model developed for a closed economy by Lucas (1975) and Barro (1980). The basic features of the Lucas-Barro type model can be summarized as follows: (i) Markets clear (ii) Information is incomplete and (iii) Expectations are formed rationally. The model developed here has these three properties and extends the analysis to cover a hypothetical world of two countries, each one producing and consuming a tradable and a nontradable good.

Several recent papers have analyzed the international transmission of economic disturbances in a context in which all goods are traded. Additionally, those papers assume alternatively, full contemporaneous information on financial variables or that contemporaneous information on some key macro-variables is not available at all[7]. A key feature of the model presented in this paper is that agents in each country observe all those variables directly linked with th markets in which they trade, but they do not have access to the information provided by the market for nontraded goods in the foreign country. Therefore, the introduction of nontraded goods, provides a natural setting for assuming an asymmetry in the information set available to agents across countries. This asymmetry is crucial for the existence of real effects associated with monetary shocks and also for the nature of the mechanism of transmission of business cycles across countries. In addition, the inclusion of nontraded goods into the picture, introduces a new channel through which business cycles are transmitted, *i.e.*, the relative price of nontraded goods or real exchange rate.

Another important feature of the model is the prominent role played by wealth in both demand and supply decisions. Since physical capital is zero in te model, then the only variable that could cause movements in wealth is the behavior of the money stock. More specifically, the real money wealth variable depends upon discrepancies between actual and expected money shocks. An unanticipated monetary shock in one country is perceived domestically as an increase in walth and therefore, will induce changes in domestic absorption. In the foreign country, the unanticipated monetary shock will induce unanticipated but observable movements in some financial variables, which in turn, will be associated partially with movements in the foreign stock of money. Since the movement in the stock of money has not occurred the discrepancy between the actual and the expected monetary disturbance will generate a wealth effect in the foreign country. The magnitude and direction of the wealth effect in each country will depend crucially upon the relative variance of monetary and real shocks in each country.

An implication of the model is that perceived changes in wealth associated with monetary or real shocks induce not only wrong decisions from the point of view of workers and therefore inefficient movements in the level for employment, but also induce wrong decisions from the point of view of producers and therefore inefficient movements of resources across sectors.

The model also implies that the exercise of policy autonomy in each country becomes more and more limited. The effects of policy induced shocks depends not only on the historical behavior of domestic money growth rates, *i.e.*, the relative variance of domestic money, but also of the historical behavior of foreign money growth rates, *i.e.*, the relative variance of foreign money. Therefore, there are likely to be incentives to coordinate economic policies between countries. Finally, the results presented in this chapter suggest that the magnitude and direction of the effects of fiscal and monetary shocks depend crucially upon the relative importance of its nontradable sector. The normative implication of this is that the economic policies should take into account the relative importance of the nontradable sector. In addition, a testable implication of the model is that the behavior during business cycles of some key variables should reflect the share of the nontradable sector.

The main findings of the paper are: First, and not surprisingly, with full information money is neutral and floating exchange rates provide complete insulation from foreign monetary innovations. Second, unanticipated monetary shocks, both foreign and domestic, affect output, relative prices and real returns in the domestic economy. Third, the pattern of comovements between the trade balance, relative prices and the nominal exchange rate will depend upon the source and the relative variance of disturbances. Fourth, business fluctuations tend to be associated with intersectoral movements of resources.

A nice feature of the model is that the results do not depend on built-in price rigidities or assumed differences in the speed of adjustment across markets. Instead, the paper emphasizes the importance of asymmetries in the information set available to agents across countries for the international transmission of business cycles.

The rest of the paper is organized as follows. Section 2 presents the basic structure of the model. Section 3 discusses the analytical solution of the model under the assumption of full information. Section 4 analyzes the implications of imperfect information. Finally, in Section 5 conclusions and suggestions for further research are presented.

2. The model

This section presents the basic structure of a two-country, two-goods equilibrium model under floating exchange rates. There are two monetary economies, each one producing and consuming two goods: a tradable good and a nontradable good. There is only one factor of production – labor – which is determined endogenously in each country. In the financial market, it is assumed that domestic and foreign bonds are perfect substitutes. in addition, financial capital is perfectly mobile across countries. These two assumptions assure uncovered interest rate parity. The market for the tradable good is completely integrated and purchasing power parity (PPP) holds at all times. Money is introduced in each country in the form of unilateral transfers by the monetary authority. Finally, the world economy faces real and monetary random disturbances and expectations are assumed to be formed rationally. In short, this means that economic agents use all current available information in forecasting the value of a given variable.

There are other simplifying assumptions and they will be introduced as the model is presented. The definition of the variables are:

Y = level of output in the tradable sector.
X = level of output in the nontradable sector.
M = nominal money supply.
P = aggregate price level.
P^y = price of tradable goods.
P^x = price of nontradable goods.
e = exchange rate.
i = nominal interest rate.
E_tZ_{t+1} = the expected value of Z at t+1 conditional on information available at time t.

All variables except i are expressed in logarithms. The subscripts 1 and 2 denote countries, the superscripts d and s indicate demand and supply respectively and t refers to time.

2.1 Goods market

The demand for trated and nontrated goods in each country are given by:

$$Y^d_{jt} = \phi_1 R^{yy}_{jt} + \phi_2 R^{yx}_{jt} + \phi_3 (P^y_{jt} - P^x_{jt}) + \phi_4 \widetilde{m}_{jt} + u_j \qquad (j = 1, 2) \quad (1.1)$$

$$X^d_{jt} = \Omega_1 R^{xx}_{jt} + \Omega_2 R^{xy}_{jt} + \Omega_3 (P^y_{jt} - P^x_{jt}) + \Omega_4 \widetilde{m}_{jt} + \eta_j \qquad (j = 1, 2) \quad (1.2)$$

where $\phi_1, \phi_2, \phi_3, \Omega_1, \Omega_2 < 0, \phi_4 \Omega_3, \Omega_4 > 0$ and

$$\widetilde{m}_{jt} = (m_{jt} - E_t m_{jt})$$

$$R^{yy}_{jt} = (i_{jt} - E_t P^y_{j,t+1} + P^y_{jt}) = [P^y_{jt} - (E_t P^y_{j,t+1} - i_t)]$$

$$R^{yx}_{jt} = (i_{jt} - E_t P^x_{j,t+1} + P^y_{jt}) = [P^y_{jt} - (E_t P^x_{j,t+1} - i_t)]$$

$$R^{xx}_{jt} = (i_{jt} - E_t P^x_{j,t+1} + P^x_{jt}) = [P^x_{jt} - (E_t P^x_{j,t+1} - i_t)]$$

$$R^{xy}_{jt} = (i_{jt} - E_t P^y_{j,t+1} + P^x_{jt}) = [P^x_{jt} - (E_t P^y_{j,t+1} - i_t)]$$

Equations (1.1) and (1.2) state that the demand for each good depends upon the current relative price of the two goods and a money-wealth variable associated with unanticipated movements in money. An unanticipated increase in money $(m_t - E_t m_t) > 0$

raises perceived wealth because individuals interpreted it as a transfer of resources to them from other individuals. On the other hand, if m_t and $E_t m_t$ rise by the same amount, people will interpret it correctly as a unilateral transfer by the government that will eventually cause an equiproportional increase in prices, leaving real balances and therefore, wealth unchanged[8]. In addition, equations (1.1) and (1.2) incorporate an intertemporal substitution effect associated with movements in current prices relative to discounted expected future prices. For example R_t^{yy} and R_t^{yx} represent the current price of y relative to the discounted expected future price of y and x respectively. On the other hand, R_t^{xx} and R_t^{xy} represent the current price of x relative to the discounted expected future price of x and y respectively. Finally, u_j and η_j are random variables with mean zero and variances σ_{uj}^2 and σ_j^2 respectively.

Under rational expectations, future expected prices correspond with those prices that would prevail when all random disturbances are zero. Replacing the expected future prices with the steady-state price values into equations (1.1) and (1.2), the demand for traded and nontrated goods can be expressed as follows:

$$Y_{jt}^d = \alpha_1 R_{jt}^y + \alpha_2 (P_{jt}^y - P_{jt}^x) + \alpha_3 \widetilde{m}_{jt} + u_j \qquad (j = 1, 2) \quad (1.1')$$

$$X_{jt}^d = \beta_1 R_{jt}^x + \beta_2 (P_{jt}^y - P_{jt}^x) + \beta_3 \widetilde{m}_{jt} + \eta_j \qquad (j = 1, 2) \quad (1.2')$$

where $\alpha_1 = \dfrac{\phi_1}{1 + \phi_1/\phi_2} < 0 \quad \beta_1 = \dfrac{\Omega_1}{1 + \Omega_1/\Omega_2} < 0$

$$\alpha_2 = \phi_3 < 0 \quad \beta_2 = \Omega_3 > 0$$

$$\alpha_3 = \phi_4 > 0 \quad \beta_3 = \Omega_4 > 0$$

and $R_{jt}^h = (i_{jt} - E_t P_{j,t+1} + P_{jt}^h) \ (j = 1, 2), \ (h = y, x).$

Equations (1.1') and (1.2') express the demand for trated and nontrated goods as a function of the one period real rate of return (R_j^h), relative prices and the money-wealth variable. The one period real rate of return in a particular market, compares current opportunities in a particular market with those anticipated for next period on average. Of course, an increase in the one period real rate of return in one market, since it raises the current price in that market relative to the discounted expected future price on average, will be associated with a decline in the demand in that particular market.

Supplies of traded and nontrated goods are obtained by equating the marginal product of labor in each sector to the own-product wage. Therefore, the supply curve in each sector can be expressed as a function of the own-product real wage[9]. Thus,

$$Y_{jt}^s = \lambda_y (W_{jt} - P_{jt}^y) + \epsilon_j \qquad (j = 1, 2) \quad (1.3)$$

$$X_{jt}^s = \lambda_x (W_{jt} - P_{jt}^x) + \gamma_j \qquad (j = 1, 2) \quad (1.4)$$

where $\lambda_h < 0 \ (h = y, x)$.

It is assumed that the nominal wage is equated across sectors and $\epsilon_j(\gamma_j)$ represents a random disturbance that affects the supply of tradables (nontradables) with mean zero and variance σ_ϵ^2 (σ_γ^2). Nominal wages are determined in the labor market by the interaction of demand for and supply of labor.

From (1.3) and (1.4) the aggregate demand for labor can be expressed as:

$$\ell_{jt}^d = (\lambda_x' + \lambda_y') W_{jt} - \lambda_y' P_{jt}^y - \lambda_x' P_{jt}^x \qquad (j = 1, 2) \quad (1.5)$$

The labor supply equation is given by

$$\ell_{jt}^s = \gamma_1 (W_{jt} - P_{jt}) + \gamma_2 R_{jt} + \gamma_3 \widetilde{m}_{jt} \qquad (j = 1, 2) \quad (1.6)$$

$$(\gamma_1 \ \gamma_2 > 0 \text{ and } \gamma_3 < 0)$$

Labor supply is a function of the real wage in terms of the consumption bundle, wealth and the current aggregate price level relative to the discounted expected future price or real interest rate. The effect of real wages and wealth are straightforward and they do not need to be explained. Movements in the current price relative to the expected future price will induce an intertemporal substitution of leisure and thereby will cause a change in the current labor supply. In particular, an increase in current prices relative to expected future prices raises the current price of leisure relative to the future price of leisure. Therefore, the supply (demand) of (for) labor (leisure) will rise (fall).

The aggregate price level in each country are weighted averages of the price in each sector. Thus,

$$P_{jt} = \theta P_{jt}^y + (1 - \theta) P_{jt}^x \qquad (j = 1, 2) \quad (1.7)$$

Substituting (1.7) into (1.6), equating (1.5) and (1.6) and solving for the equilibrium wage we obtain

$$W_{jt} = \rho_1 P_{jt}^y + (1 - \rho_1) P_{jt}^x + \rho_2 R_{jt}^y + \rho_3 \widetilde{m}_{jt} \qquad (j = 1, 2) \quad (1.8)$$

where $\rho_1 = \dfrac{\lambda_y' - \gamma_1 \theta - \gamma_2 (1 - \theta)}{\lambda_y' + \lambda_x' - \gamma_1} > 0, \quad \rho_2 = \dfrac{\gamma_2}{\lambda_y' + \lambda_x' - \gamma_1} < 0$

$$\rho_3 = \frac{\gamma_3}{\lambda_y' + \lambda_x' - \gamma_1} > 0$$

The intuition behind the sign of these coefficients is the following:

(i) An increase in the price of Y for a given nominal wage, reduces the real wage in terms of Y and therefore induces an increase in the demand for labor in sector Y. On the other hand, the higher price of Y reduces the real wage in terms of the consumption bundle and therefore produces a fall in the aggregate supply of labor. The increase in the demand for labor and the decline in the supply of labor associated with the increase in the supply of labor associated with the increase in the price of Y requires an increase in the nominal wage ($\rho_1 > 0$).

(ii) A reduction in the one-period real interest rate in terms of Y for a given P^x and P^y is equivalent to a fall in the aggregate real interest rate. Thus, the supply of labor is reduced and the nominal wage should increase ($\rho_2 < 0$).

(iii) A rise in the level of perceived wealth reduces the supply of labor and therefore causes an increase in the nominal wage ($\rho_3 > 0$).

Substituting equation (1.8) into (1.3) and (1.4) respectively, we have

$$Y^s_{jt} = a_1 R^y_{jt} + a_2 (P^y_{jt} - P^x_{jt}) + a_3 \tilde{m}_{jt} + \epsilon_j \qquad (j = 1, 2) \quad (1.9)$$

$$X^s_{jt} = b_1 R^x_{jt} + b_2 (P^y_{jt} - P^x_{jt}) + b_3 \tilde{m}_{jt} + v_j \qquad (j = 1, 2) \quad (1.10)$$

where

$a_1 = \lambda_y \rho_2 > 0 \qquad b_1 = \lambda_x \rho_2 > 0$

$a_2 = \lambda_y (\rho_1 - 1) \lesseqgtr 0 \qquad b_2 = \lambda_x (\rho_1 + \rho_2) \lesseqgtr 0$

$a_3 = \lambda_y \rho_3 < 0 \qquad b_3 = \lambda_x \rho_3 < 0.$

Output in each sector is positively correlated with the one period real rate of return and negatively correlated with unanticipated monetary disturbances[10]. The effect of relative prices is ambiguous, reflecting a mix of redistribution of labor across sectors and movements in labor supply. In the rest of the paper, it is assumed that $a_2 > 0$ and $b_2 < 0$.

The equilibrium conditions in both the market for tradable and nontradable goods are:

$$\sum_{j=1}^{2} (Y^s_{jt} - Y^d_{jt}) = 0 \qquad (1.11)$$

$$X^s_{jt} - X^d_{jt} = 0 \qquad (j = 1, 2) \quad (1.12)$$

In the tradable sector, as shown in equation (1.11), the equilibrium requires that the excess demand for tradables in one country be equal to the excess supply in the other country. In the nontradable sector, the equilibrium requires that domestic output be equal to domestic consumption in each country.

2.2 Money market

The money supply process in the two countries is specified as follows:

$$M^s_{jt} = \bar{M}_j + m_{jt} \qquad (j = 1, 2) \quad (1.13)$$

where $\bar{M}_j$ represents the steady-state level of the stock of money and m_j are country-specific monetary disturbances with mean zero and variance σ^2_{mj}.

The demand for real balances in each country is given by

$$M^d_{jt} - P_{jt} = \ell i_{jt} \qquad (j = 1, 2) \quad (1.14)$$

Equation (1.14) states that the demand for real balances depends on the opportunity cost of holding money. The usual constant term has been normalized to zero. The parameter $\ell < 0$ represents the semi-elasticity of money demand with respect to the interest rate.

Finally, the equilibrium condition is given by:

$$M^s_{jt} = M^d_{jt} \qquad (j = 1, 2) \quad (1.15)$$

2.3 International linkages

In the tradable sector the "law of one price" holds through commodity arbitrage and therefore

$$P^y_{1t} = P^y_{2t} + e_t \qquad (1.16)$$

In logs, commodity arbitrage equates the domestic currency price of the foreign currency price plus the nominal exchange rate.

In the capital market, domestic and foreign bonds are perfect substitutes and with perfect capital mobility uncovered interest rate parity holds

$$i_{1t} = i_{2t} + E_t e_{t+1} - e_t \qquad (1.17)$$

2.4 Preliminary solution

The basic model consists of a set of 23 equations, which can be used to solve for the vector of 23 endogenous variables. In particular, the semi-reduced form solution for the vector of variables $P'_t = [i_{1t}, P^y_{1t}, P^x_{1t}, P^x_{2t}, e_t]$ can be expressed as follows (see Appendix II).

$$P_t = \Lambda^{-1} Z_t \qquad (1.18)$$

where Λ is a (5x5) matrix of coefficients and Z_t is a (5x1) vector of predetermined variables ($\bar{M}_1$, $\bar{M}_2$), stochastic disturbances (m_{1t}, m_{2t}, s, ρ_1, ρ_2) and expected values ($E_t P_{j,t+1}$, $E_t e_{t+1}$, $E_t m_{jt}$).

Under rational expectations, since the random variables have a zero mean, the current expected future value for the variables of the system should coincide with the steady-state solution for these variables. Thus, $E_t P_{j,t+1} = \bar{P}_j$ for j = 1, 2 and $E_t e_{t+1} = \bar{e}$. The steady-state solution for P_1 and e is given by

$$P_1 = (A_1 B_2^2 - A_2 B_1 B_2) \frac{(\bar{M}_1 - \bar{M}_2)}{\Delta} \qquad (1.19)$$

$$e = 2(A_1 B_2^2 - A_2 B_1 B_2) \frac{(\bar{M}_1 - \bar{M}_2)}{\Delta} \qquad (1.20)$$

Substituting (1.19) and (1.20) into equation (1.18), the vector of prices P_t can be expressed as a function of present and future levels of the stock of money in each country, current real shocks and unanticipated monetary disturbances. In order to solve the model for the endogenous variables one must specify the information set available to agents. In the next two sections I consider the analytical solution of the model under: (1) Full current information and (2) Incomplete current information.

3. Full current information

Suppose that initially the world economy is in steady-state equilibrium with the domestic money supply in each country equal to $\bar{M}_1$ and $\bar{M}_2$ respectively. The solution for the vector of prices in each country is given by

$$P_j^h = (AB_2^2 - 2B_1B_2A_2)\frac{M_j}{\Delta} \quad \begin{matrix}(j=1,2)\\(h=y,x)\end{matrix} \tag{1.21}$$

Therefore, the steady-state solution for the exchange rate is given by

$$e = (AB_2^2 - 2B_1B_2A_2)\frac{(M_1 - M_2)}{\Delta} \tag{1.22}$$

In addition, equation A.I.8 (see Appendix I) shows that interest rates are equalized in the two countries ($E_te_{t+1} = e_t = e$) and equation A.I.12 shows that real rates are equalized across sectors ($E_tP_{j,t+1} = P_{jt}^h = \bar{P}_j$). Thus, in steady-state

$$i_1 = i_2 = R_j^h \quad \begin{matrix}(j = 1,2)\\(h = y,x)\end{matrix} \tag{1.23}$$

From equation (1.21) we can see that the relative price of tradables is independent of the level of M_1. In addition, since present and future prices move in the same direction and by the same amount, the once period real rate of return is also unaffected. On the other hand, from equations (1.21) and (1.22), we can see that the price of the tradable good in country 1 raises by the same amount of the nominal exchange rate as M_1 goes up ($P_1^y - e$). An implication of this is that the price of the tradable good in country 2 is not affected. In summary, the model implies that the real sector is independent of the monetary sector and that floating exchange rates provide full insulation of real and nominal variables from permanent monetary innovations originated in the foreign country under full current information.

4. The impact of imperfect information

This section relaxes the assumption of full information and considers the implications of limiting the current information set of both domestic and foreign agents to those variables directly linked with the markets in which they usually trade.

The absence of full information is implemented by assuming that the price of the nontradable good in country 1 is not observed in country 2 and vice-versa. All past endogenous and exogenous variables and the current value of the domestic interest rate are part of the information set available to agents. The foreign interest rate and the price of tradable goods abroad have been dropped out of the information set because they do not provide additional information. The information set at time t denoted by S_t, is therefore given by

$$S_t^j = [i_t^j, P_{jt}^y, P_{jt}^x, e_t, g_t] \quad (j = 1,2) \tag{1.24}$$

where g_t summarizes the lagged values of all the variables in the system. In addition, agents know the true structure of the model, including the first and second moments of the distribution of the random disturbances.

The state of the world economy can be fully described by the set $[Q_t, N_t]$ where $Q_t' = [\bar{M}_{1t}, \bar{M}_{2t}]$ is the vector of predetermined variables and $N_t' = [m_{1t}, m_{2t}, s_t, \rho_{1t}, \rho_{2t}]$ is the vector on random disturbances. Given the simple log-linear structure of the model it is assumed that the solution for the vector $R_{jt}' = [i_{jt}, P_{jt}^y, P_{jt}^x, e_t]$ is a linear combination of the vector of predetermined variables and the vector of stochastic disturbances. Thus, the conjectured solution for the vector R_{jt} is given by:

$$R_{jt} = \pi_{1t}Q_t + \pi_{2j}N_t \quad (j = 1,2) \tag{1.25}$$

where π_{1j} and π_{2j} are respectively (4x2) and (4x5) matrices of undetermined coefficients. The expected value of the vector R_{jt} at t conditional on information available at time t–1 is

$$E_{t-1}R_{jt} = \pi_{1j}E_{t-1}Q_t + \pi_{2j}E_{t-1}N_t \quad (j = 1,2) \tag{1.26}$$

since $E_{t-1}Q_t = Q_t$ and $E_{t-1}N_t = 0$

$$E_{t-1}R_{jt} = \pi_{1j}Q_t \quad (j = 1,2) \tag{1.27}$$

Therefore, the vector of unanticipated price movements based on prior information is given by $R_{jt} = R_{jt} - E_{t-1}R_{jt}$. Thus

$$R_{jt} = \pi_{2j}N_t \quad (j = 1,2) \tag{1.28}$$

Equation (1.28) states that unanticipated movements in prices are a linear function of the stochastic disturbances.

The problem that agents face in each country is to infer the source and size of the disturbances given the information provided by unanticipated price moements. Formally, observing $\bar{R}_{jt}$, the optimal (least squares) predictor of a monetary innovation in each country is

$$E_tm_{jt} = \sigma_{mj}^2(\pi_{2j}\Sigma\pi_{2j}')^{-1}\pi_{2j}^j\bar{R}_{jt} \quad (j = 1,2) \tag{1.29}$$

where Σ is a diagonal matrix of stochastic shocks and π_{2j}^j represents the j column of the matrix of coefficients π_{2j}.

The wealth effect associated with unanticipated movements in the stock of money is given by.

$$\bar{m}_{jt} = m_{jt} - \sigma_{mj}^2(\pi_{2j}\Sigma\pi_{2j}')^{-1}\pi_{2j}^j\bar{R}_{jt} \quad (j = 1,2) \tag{1.30}$$

Substituting (1.30) into (A.I.11) the system consisting of equations (A.I.1-A.I.12) is solved. However, closed form solutions are not available in general. Despite this, certain qualitative properties of interest appear when the transmission of disturbances is analyzed in limiting cases. In the rest of the section, I will analyze the transmission of monetary and fiscal shocks.

4.1. Unanticipated monetary disturbances in both countries

Consider the extreme case in which monetary disturbances are completely unanticipated in each country, so that $E_tm_{jt} = 0$ $(j = 1,2)$ and therefore, $\bar{m}_{jt} = m_{jt}$ $(j = 1,2)$. In other words, unanticipated price movements will be largely attributed to the occurrence of excess demand disturbanes in the tradable and/or the nontradable sector. This situation would occur when the variance of monetary disturbances in both countries approach zero. A temporary monetary innovation in country 1 will generate a wealth effect and therefore demand pressures in both the tradable and nontradable markets. The aggregate price level will rise by more and the interest rate will fall by less than in the case of a fully perceived temporary monetary expansion. As a result of the movements in prices and interest rate, the real return in terms of X and/or Y will also rise. The effect on the relative price of tradables in principle, is ambiguous, and it will depend on the excess demand-price elasticities in both the tradable and nontradable sector. However, since a change in the price level in the tradable sector induce movements in output in both countries, it is expected under normal circumstances, that the relative price of tradables in country 1 will fall.

Formally, the semi-reduced forms of relative prices and real rates of return in country 1 are.

$$R^y_{1t} = \bar{i}_{1t} - \frac{1}{\Delta_1}[H^2A_3 + A_2HB_3][\bar{m}_{1t} + \bar{m}_{2t}] + \frac{H^2}{\Delta_1}s + \frac{[A_2H]}{\Delta_1}(\rho_1+\rho_2) \quad (1.31)$$

$$R^x_{1t} = \bar{i}_1 - \frac{1}{\Delta_1}[B_2HA_3 - (A_2B_2+BH)B_3]\bar{m}_{1t} + \frac{1}{\Delta_1}[B_2HA_3+A_2B_2B_3]\bar{m}_{2t}$$

$$-\frac{1}{\Delta_1}[B_2H]s + \frac{1}{\Delta_1}[A_2B_2+BH]\rho_1 - \frac{1}{\Delta_1}[A_2B_2]\rho_2 \quad (1.32)$$

$$(P^y_{1t}-P^x_{1t}) = -\frac{1}{\Delta_1}[B_1HA_3-(AH+A_2B_1)B_3]\bar{m}_{1t} - \frac{1}{\Delta_1}[B_1HA_3+A_2B_1B_3]\bar{m}_{2t}$$

$$+\frac{1}{\Delta_1}[B_1H]s - \frac{1}{\Delta_1}[AH+A_2B_1]\rho_{1t} + \frac{1}{\Delta_1}[A_2B_1]\rho_{2t} \quad (1.33)$$

and

$$\frac{\Delta R^x_{1t}}{\Delta\bar{m}_{1t}} = \frac{1}{\Delta_1}[B_2HA_3-(A_2B_2+BH)B_3]>0 \quad (1.34)$$

$$\frac{\Delta R^y_{1t}}{\Delta\bar{m}_{1t}} = -\frac{1}{\Delta_1}[H^2A_3+A_2HB_3]>0 \quad (1.35)$$

$$\frac{\Delta(P^y_{1t}-P^x_{1t})}{\Delta\bar{m}_{1t}} = -\frac{1}{\Delta_1}[B_1HA_3-(AH+A_2B_1)B_3] \gtrless 0 \quad (1.36)$$

By analogy, the effects on relative prices and real rates in country 2 are.

$$\frac{\Delta R^y_{2t}}{\Delta\bar{m}_{1t}} = -\frac{1}{\Delta_1}[H^2A_3+A_2HB_3] > 0 \quad (1.37)$$

$$\frac{\Delta R^x_{2t}}{\Delta\bar{m}_{1t}} = \frac{1}{\Delta_1}[B_2HA_3+A_2B_2B_3] > 0 \quad (1.38)$$

and

$$\frac{\Delta(P^2_{2t}-P^x_{2t})}{\Delta\bar{m}_{1t}} = -\frac{1}{\Delta_1}[B_1HA_3+A_2B_1B_3] > 0 \quad (1.39)$$

In country 2, the unanticipated monetary expansion in country 1 increases both the real rates of return across sectors and the relative price of tradable goods. As a result of this, output will rise and domestic demand will fall causing a balance of trade surplus in country 2. In the nontradable sector, output could increase or decrease depending on the relative size of the intertemporal substitution effect and the relative price effect. The effect on global employment is, of course, ambiguous. In country 1 the effect on the relative price of tradable goods will be in general negative. Therefore, output and employment will move in oposite directions as in the case of country 2. The balance of trade in country 1 has to deteriorate to accommodate the intertemporal budget constraint.

In summary, when unanticipated movements in prices are attributed ins both countries to non-monetary shocks, a monetary innovation in one country will induce in general, movements in relative prices of opposite direction across countries and therefore will cause asymetric effects in output and employment across sectors, between countries.

Finally, note that both foreign and domestic monetary shocks increase the real rate of return across sectors. The intuition behind it is that the wealth effect associated with unanaticipated monetary expansions induce higher pressures on prices in the current period than in the case of a fully perceived temporary monetary expansion. Therefore, the expected future deflation and hence the real return will be higher for unanticipated monetary disturbances relative to anticipated monetary innovations.

4.2. Positive international transmission of wealth

Consider the case where σ^2_{m2} and σ^2_s are so large relative to $\sigma^2_{m1}, \sigma^2_{\rho1}$, and $\sigma^2_{\rho2}$, that most of the variability in prices is attributable to monetary disturbances in country 2 and/or temporary excess demand disturbances in the tradable sector.

In this case, a monetary innovation in country 1 will be entirely unanticipated so that $E_t m_{1t} = 0$ and $\bar{m}_{1t} = m_{1t}$. In country 2, unanticipated price movements will be attributed, in principle, to domestic monetary innovations and temporary excess demand shocks in the tradable sector. Moreover, the semi-reduced form of the nominal exchange rate can be expressed as follows (see Appendix III).

$$e_t = F_1\bar{e} + F_2(\bar{M}_1 + m_{1t} - \bar{M}_2 - m_{2t}) + F_3(\bar{m}_{1t} - \bar{m}_{2t}) + F_4(\rho_2-\rho_1). \quad (1.40)$$

Since $\bar{m}_{1t} = m_{1t}$, the actual change in the exchange rate is given by

$$e_t = (F_2+F_3)m_{1t} \quad (1.41)$$

In country 2, since unanticipated movements in the exchange rate depend only on monetary disturbances and excess demand disturbances in the nontradable sector and the fact that $\sigma^2_{m1}, \sigma^2_{\rho 1}$ and $\sigma^2_{\rho 2}$ approach to zero, the actual change in the exchange rate will be attributed to a monetary disturbance in country 2. From (1.40) the perceived monetary innovation in country 2 is given by.

$$E_t m_{2t} = \frac{-\Delta e_t}{(F_2+F_3)} \qquad (1.42)$$

Substituting the actual change in the exchange rate given by (1.40) into equation (1.42).

$$E_t m_{2t} = -m_{1t} \qquad (1.43)$$

Now, since $\bar{m}_{2t} = m_{2t} - E_t m_{2t}$ and the fact that $m_{2t} = 0$, then the unanticipated monetary innovation in country 2 is given by

$$\bar{m}_{2t} = m_{1t} = \bar{m}_{1t} \qquad (1.44)$$

Substituting (1.44) into equations (1.31) – (1.33) the solution for the impact effect on relative prices and real rates are

$$\frac{\Delta R^y_{jt}}{\Delta m_{1t}} = -\frac{2}{\Delta_1}[H^2 A_3 + A_2 H B_3] > 0 \qquad (j=1,2)\ (1.45)$$

$$\frac{\Delta R^x_{jt}}{\Delta m_{1t}} = \frac{2}{\Delta_1}[B_2 H A_3 - (A_1 - A_2) H B_3] > 0 \qquad (j=1,2)\ (1.46)$$

$$\frac{\Delta (P^y_{jt} - P^x_{jt})}{\Delta m_{1t}} = -\frac{2}{\Delta_1}[B_1 H A_3 - A_1 H B_3] \gtrless 0 \qquad (j=1,2)\ (1.47)$$

Equations (1.45) – (1.47) imply complete synchronization of the business cycles across countries. Since movements in the real rate of return and relative prices are symmetric across countries, movements in output and employment across sectors will be the same in both countries. An implication of this is that the balance of trade in each country will be unaffected by unexpected monetary innovations.

4.3. The impact effect of fiscal policies

Let us suppose that there is a temporary fiscal expansion in country 1. In order to isolate the impact effect of a fiscal shock, we assume that the variance of monetary disturbances in both countries approach to zero and therefore, there is no wealth effect associated with excess demand disturbances. In addition, we assume that the fiscal expansion is distributed symmetrically across sectors ($s = \zeta_1$).

Formally, the impact effect of a temporary fiscal expansion upon relative prices and the one-period real rates of return at home and abroad is

$$\frac{\Delta R^y_{jt}}{\Delta F} = \frac{1}{\Delta_1}(A_2 H + H^2) > 0 \qquad (1.48)$$

$$\frac{\Delta R^x_{1t}}{\Delta F} = \frac{1}{\Delta_1}(AH + A_2 H + A_2 B_1 - B_2 H) > 0 \qquad (1.49)$$

$$\frac{\Delta R^x_{2t}}{\Delta F} = \frac{1}{\Delta_1}(A_2 B_2 + B_2 H) > 0 \qquad (1.50)$$

$$\frac{\Delta (P^y_{1t} - P^x_{1t})}{\Delta F} = \frac{1}{\Delta_1} H(B_1 - 2A_1) - A_2 B_1 \gtrless 0 \qquad (1.51)$$

$$\frac{\Delta (P^y_{2t} - P^x_{2t})}{\Delta F} = \frac{1}{\Delta_1}(B_1 H + A_2 B_1) > 0 \qquad (1.52)$$

where $\Delta_1 = (AH^2 + 2 A_2 B_1 H) > 0$ and $F = s + \zeta_1$, is the aggregate fiscal shock. The rest of the coefficients are defined in Appendix III.

The fiscal shock raises real interest rates worldwide. Moreover, in the foreign country, both, the intertemporal substitution effect and the relative price effect will induce an excess supply in the tradable sector. Therefore, the balance of trade at home will deteriorate and abroad will improve.

The effect of the expansionary fiscal policy upon the domestic relative price of traded goods is in general ambiguous. However, equation (1.51) suggests that under normal circumstances, a positive fiscal shock will induce a fall in the relative price of traded goods at home.

In other words, since, in general, fiscal shocks tend to generate movements in relative prices of opposite directions across countries, they could eventually create asymmetric movements in employments across sectors at home and abroad.

Finally, an interesting implication of the model is that fiscal policies are not neutral across sectors. In general, for plausible values of the parameters, expansionary fiscal policies tend to be biased againsts the tradable sector.

5. Concluding remarks

The purpose of this paper has been to develop a simple equilibrium model in order to analyze the interactions between two large economies subject to random monetary and real disturbances. Specifically, the paper is an attempt to explain the joint behavior of relative prices, real interest rates and the balance of trade across countries within a context in which feedback effects are explicity considered. In addition, the inclusion of a nontradable sector has interesting implications for the nature of the international transmission process. First, introduces a new channel through which economic disturbances are transmitted. Second, intoduces a source of asymmetry in the information set available to agents across countries.

It has been shown that fully perceived monetary innovations have no real effects while unanticipated monetary disturbances do have real effects. The real effects that are induced by unanticipated monetary innovations are the result of the perceived change in wealth associated with a monetary disturbance. The pattern of co-movement between the exchange rate, real interest rates, relative prices and the balance of trade is in general ambiguous. This is so because the sign of the correlation between these variables depends crucially upon the origin, source and relative variance of the disturbances. Finally, it was shown that a flexible exchange rate system does not fully insulate domestic variables from foreign monetary disturbances and/or foreign excess demand shocks. The insulation property holds only for anticipated monetary disturbances.

The framework of analysis utilized in this paper can be extended in many ways, although at the cost of increased complexity. One relatively simple extension is to incorporate explicity the distinction between permanent and transitory shocks. Another is to investigate the consequences of relaxing the assumption of uncovered interes rate parity, and introduce limited capital mobility in the model. Once this is done, the balance of payments would play a more prominent role in exchange rate determination. A much more interesting extension, however, would be to explore the implications of alternative forms of cooperative behavior between the two monetary authorities. Specifically, how do the monetary authorities in both countries can design a set of incentives that induces private agents in one country to reveal information to agents in another country that is useful in stabilizing the economy? In this paper we have assumed that the cost of transmitting information related with the nontradable sector was infinite. Naturally this is an extreme assumption. Finally, the transmission process was discussed within the context of flexible exchange rates. A natural extension would be to compare the implications of the model sunder alternative exchange rate regimes.

Notes

1 For a general discussion on interdependence see Cooper (1984) and Dornbusch (1983). On international transmission through the terms of trade see Hamada and Sakurai (1978), Mussa (1979) and Corden and Turnovsky (1983).

2 See, for instance, Huber and Saidi (1982) and Swoboda (1983).

3 An expansionary fiscal policy abroad tends to raise the interest rate in the foreign country inducing a capital flow from the home country to the foreign country. This leads to a depreciation of the home currency which partially offset the initial expansion abroad, while inducing an increase in the demand for domestic product (positive transmission). On the other hand, a monetary expansion abroad tends to reduce the nominal interest rate abroad, inducing capital inflows to the currency. This leads to a decline in the demand for foreign goods and reinforces the initial expansion in the demand for foreign goods originated by the monetary expansion (negative transmission).

4 For a comparison of Keynesian models and equilibrium models see Kimbrough and Koray (1984).

5 It is clear that money is an important source of business fluctuations and that the choice of monetary regime affects the mechanism of transmission of economic disturbances.

6 King and Plosser (1984) suggest that the positive correlation between the rates of growth in output and monetary aggregates reflects, in large part, "the causal chain running from business activity to inside money".

7 See Turnovsky (1985), Bhandari (1982), Frenkel and Razin (1985) and Weber (1981).

8 See Barro (1980) and Lawrence (1984).

9 Suppose the production function in each sector are:

$$\bar{Y}_t = L^{-a} \quad (a < 1) \qquad (1.1')$$

$$\bar{X}_t = L^{-b} \quad (b < 1) \qquad (1.2')$$

The first order conditions for profit maximization imply

$$a\ L^{-a-1} \cdot \bar{P}_y = \bar{W} \qquad (1.3')$$

$$b\ L^{-b-1} \cdot \bar{P}_x = \bar{W} \qquad (1.4')$$

Form (1.3') and (1.4') the demand for labor in each sector can be expressed as

$$\bar{L}_y = \left[\frac{\bar{W}}{a\bar{P}_y}\right]^{1/a-1} \qquad (1.5')$$

$$\bar{L}_x = \left[\frac{\bar{W}}{b\bar{P}_x}\right]^{1/b-1} \qquad (1.6')$$

Overbars refer to the level of the variables. Taking logs in (1.5') and (1.6') we have

$$\ell_y = \frac{1}{a-1}(W-P_y) - \frac{a'}{a-1} \qquad (1.7')$$

$$\ell_x = \frac{1}{b-1}(W-P_x) - \frac{b'}{b-1} \qquad (1.8')$$

Finally, adding (1.7') and (1.8') we obtain the aggregate demand for labor

$$\ell = \ell_x + \ell_y = (\lambda'_y + \lambda'_x)W - \lambda'_y P_y - \lambda'_x P_x - \left(\frac{a'}{a-1} + \frac{b'}{b-1}\right) \qquad (1.9')$$

Replacing (1.5') and (1.6') into the production function we obtain

$$Y_t = \lambda_y (W-P_y) - \frac{a\ a'}{a-1} \qquad (1.10')$$

$$X_t = \lambda_x (W-P_x) - \frac{b\ b'}{b-1} \qquad (1.11')$$

where $\lambda_y = \frac{a}{a-1}$, $\lambda_x = \frac{b}{b-1}$, $\lambda'_y = \frac{\lambda_y}{a}$ and $\lambda'_x = \frac{\lambda_x}{b}$

In the text the terms a'/a−1 and b'/b−1 have been eliminated, since they do not alter the substance of the results.

10 An increase in the real rate of return reduces the demand for leisure, increases the supply of labor and thereby reduces the real wage in both sectors. This, in turn, increases employment and output. On the other hand, an unexpected monetary expansion induces a positive wealth effect, which reduces the supply of labor and therefore employment and output in each sector.

Appendix I

The structure of the model

The purpose of this appendix is to summarize the basic structure of the model.

$$Y^s_{jt} = a_1 R^y_{jt} + a_2 (P^y_{jt} - P^x_{jt}) + a_3 \widetilde{m}_{jt} + \epsilon_j \qquad (j = 1,2) \quad (A.I.1)$$

$$a_1, a_2 > 0 \qquad a_3 < 0 \qquad \epsilon_j \sim N(0, \sigma^2_{\epsilon j})$$

$$Y^d_{jt} = \alpha_1 R^y_{jt} + \alpha_2 (P^y_{jt} - P^x_{jt}) + \alpha_3 \widetilde{m}_{jt} + u_j \qquad (j = 1,2) \quad (A.I.2)$$

$$\alpha_2, \alpha_1 < 0 \qquad \alpha_3 > 0 \qquad u_j \sim N(0, \sigma^2_{uj})$$

$$X^s_{jt} = b_1 R^x_{jt} + b_2 (P^y_{jt} - P^x_{jt}) + b_3 \widetilde{m}_{jt} + \gamma_j \qquad (j = 1,2) \quad (A.I.3)$$

$$b_1 > 0 \qquad b_2, b_3 < 0 \qquad \gamma_j \sim N(0, \sigma^2_{\gamma j})$$

$$X^d_{jt} = \beta_1 R^x_{jt} + \beta_2 (P^y_{jt} - P^x_{jt}) + \beta_3 \widetilde{m}_{jt} + \eta_j \qquad (j = 1,2) \quad (A.I.4)$$

$$\beta_3, \beta_2 > 0 \qquad \beta_1 < 0 \qquad \eta_j \sim (0, \sigma^2_{\eta j})$$

$$\sum_{j=1}^{2} (Y^s_{jt} - Y^d_{jt}) = 0 \qquad (j = 1,2) \quad (A.I.5)$$

$$X^s_{jt} - X^d_{jt} = 0 \qquad (j = 1,2) \quad (A.I.6)$$

$$\bar{M}_j + m_{jt} = P_{jt} + \ell i_{jt} \qquad (j = 1,2) \quad (A.I.7)$$

$$i_{1t} = i_{2t} + E_t e_{t+1} - e_t \qquad (A.I.8)$$

$$P_{jt} = \theta P^y_{jt} + (1-\theta) P^x_{jt} \qquad (A.I.9)$$

$$P_{jt} = \theta P^y_{jt} + (1-\theta) P^x_{jt} \qquad (A.I.10)$$

$$\widetilde{m}_{jt} = m_{jt} - E_t m_{jt} \qquad (j = 1,2) \quad (A.I.11)$$

$$R^h_{jt} = i^h_{jt} - E_t P_{j,t+1} + P^h_{jt} \qquad (j = 1,2) \ (h = y, x) \quad (A.I.12)$$

where

Y = level of output in the tradable sector
X = level of ouptut in the nontradable sector
M = nominal money supply
P = aggregate price level
P^y = price of tradable goods
P^x = price of nontradable goods
e = exchange rate
i = nominal interest rate
$E_t Z_{t+1}$ = the expected value of Z at t+1 conditional on information available at time t.

All variables except i are expressed in logarithms. The subscripts 1 and 2 denote countries, the superscripts d and s indicate demand and supply respectively and refers to time.

Appendix II

The steady solution of the model

This appendix presents the solution for the vector of prices $P' = [i_1, P^y_1, P^x_1, P^x_2, e]$ in steady state.

Setting $\epsilon_j = u_j = \gamma_j = \eta_j = m_j = E_j m_j = 0$, substituting (A.I.1) and (A.I.2) into (A.I.5), (A.I.3) and (A.I.4) into (A.I.6), (A.I.8), (A.I.9) and (A.I.10) into (A.I.7) and solving for the vector of prices P, we obtain

$$\begin{bmatrix} i_1 \\ P^y_1 \\ P^x_1 \\ P^x_2 \\ e \end{bmatrix} = \begin{bmatrix} A & 2A_2 & -A_2 & -A_2 & -A_2 \\ B_1 & B_2 & -B_2 & 0 & 0 \\ B_1 & B_2 & 0 & -B_2 & -B_2 \\ -\ell & -\theta & -(1-\theta) & 0 & 0 \\ -\ell & -\theta & 0 & -(1-\theta) & -\ell \end{bmatrix}^{-1} \begin{bmatrix} 0 \\ 0 \\ 0 \\ \bar{M}_1 \\ \bar{M}_2 \end{bmatrix} \qquad (A.II.1)$$

The solution for the vector of endogenous variables is

$$i_1 = i_2 = 0 \qquad (A.II.2)$$

$$P^y_1 = P^x_1 = (A_1 B_2^2 - A_2 B_1 B_2)\, 2\, \frac{\bar{M}_1}{\Delta} \qquad (A.II.3)$$

$$P^y_2 = P^x_2 = (A_1 B_2^2 - A_2 B_1 B_2)\, 2\, \frac{\bar{M}_2}{\Delta} \qquad (A.II.4)$$

$$e = (A_1 B_2^2 - A_2 B_1 B_2)\, 2\, \frac{(\bar{M}_1 - \bar{M}_2)}{\Delta} \qquad (A.II.5)$$

where $\Delta = -[AB_2^2 + 2A_2 B_1 B_2](1-\ell) > 0$

Appendix III

The general solution

The general solution for the vector of prices in terms of predetermined variables, stochastic real disturbances and unanticipated monetary innovations can be expressed as follows:

$$\begin{bmatrix} i_{it} \\ P^y_{it} \\ P^x_{it} \\ P^x_{2t} \\ e_t \end{bmatrix} = \begin{bmatrix} A & B & -A_2 & -A_2 & -A_2 \\ B_1 & B_2 & H & 0 & 0 \\ B_1 & B_2 & 0 & H & H \\ -\ell & -\theta & -(1-\theta) & 0 & 0 \\ -\ell & -\theta & 0 & -(1-\theta) & (e-\ell) \end{bmatrix}^{-1} \begin{bmatrix} z_1 \\ z_2 \\ z_3 \\ z_4 \\ z_5 \end{bmatrix}$$

where

$A = 2A_1$ $\qquad z_1 = AE_tP_{1t+1} - A_3\widetilde{m}_{1t} + s$

$B = 2A_1 + 2A_2$ $\qquad z_2 = B_1E_tP_{1t+1} - B_3\widetilde{m}_{1t} + \rho_1$

$H = B_1 - B_2$ $\qquad z_3 = B_1E_tP_{1t+1} - B_3\widetilde{m}_{2t} + \rho_2$

$A_i = a_i - \alpha_i$ $\qquad z_4 = -M_{1t}$

$B_i = b_i - \beta_i$ $\qquad z_5 = -M_{2t} - \ell E_te_{t+1}$

$\rho_i = \eta_i - \gamma_i$ $\qquad s = u_1 + u_2 - \epsilon_1 - \epsilon_2$

The solution for the vector of endogenous variables is

$$\begin{aligned} i_1 = {} & C_0 - \frac{1}{\Delta_1'}[BH^2 + 2A_2B_2H]\,(M_1 + m_1) - \frac{1}{\Delta_1'}\Big\{ [H^2\theta - B_2H(1-\theta]A_3 \\ & + [A_2H\theta + A_2B_2(1-\theta) + BH(1-\theta)]B_3 \Big\}\,\widetilde{m}_1 - \frac{1}{\Delta_1'}\Big\{ [H^2\theta - B_2H(1-\theta)]A_3 \\ & + [A_2H\theta - A_2B_2(1-\theta)]B_3 \Big\}\,\widetilde{m}_2 + \frac{1}{\Delta_1'}[H^2\theta - B_2H(1-\theta)]\,s \\ & + \frac{1}{\Delta_1'}[A_2H\theta + A_2B_2(1-\theta) + BH(1-\theta)]\,\rho_1 + \frac{1}{\Delta_1'}[A_2H - A_2B_2(1-\theta)]\rho_2 \end{aligned} \quad (A.III.1)$$

$$\begin{aligned} P_1^y = {} & C_1 + \frac{1}{\Delta_1'}[AH^2 + 2A_2B_1H]\,(M_1 + m_1) - \frac{1}{\Delta_1'}\Big\{ [B_1H(1-\theta) - H^2\ell]A_3 \\ & - [AH(1-\theta) + A_2H\ell + A_2B_1(1-\theta)] \Big\} - \frac{1}{\Delta_1'}\Big\{ [BH(1-\theta) - H^2\ell]A_3 \\ & + [A_2B_1(1-\theta) - A_2H\ell]B_3 \Big\}\,\widetilde{m}_2 + \frac{1}{\Delta_1'}[B_1H(1-\theta) - H^2\ell]\,s \\ & - \frac{1}{\Delta_1'}[AH(1-\theta) - A_2H\ell + A_2B_1(1-\theta)]\rho_1 + \frac{1}{\Delta_1'}[A_2B_1(1-\theta) - A_2H\ell]\rho_2 \end{aligned} \quad (A.III.2)$$

$$\begin{aligned} P_1^x = {} & C_2 - \frac{1}{\Delta_1'}[AB_2H - BB_1H]\,(M_1 + m_1) - \frac{1}{\Delta_1'}\Big\{ [B_2H\ell - B_1H\theta]A_3 \end{aligned}$$

$$\begin{aligned} & + [AH\theta - BH\ell + A_2B_1\theta - A_2B_2\ell]B_3 \Big\}\,\widetilde{m}_1 - \frac{1}{\Delta_1'}\Big\{ [B_2H\ell - B_1H\theta]A_3 \\ & + [A_2B_2\ell - A_2B_1\theta]B_3 \Big\}\,\widetilde{m}_2 + \frac{1}{\Delta_1'}[B_2H\ell - B_1H\theta]\,s \\ & + \frac{1}{\Delta_1'}[AH\theta - BH\ell + A_2B_1\theta - A_2B_2\ell]\rho_1 + \frac{1}{\Delta_1'}[A_2B_2 1 - A_2B_1\theta]\rho_2 \end{aligned} \quad (A.III.3)$$

$$\begin{aligned} e = {} & C_3 + \frac{1}{\Delta_1'}[AH^2 + 2A_2B_1H]\,[M_1 + m_1 - M_2 - m_2] + \frac{B_3}{\Delta_1'}[AH(1-\theta) \\ & + 2A_2B_1(1-\theta)]\,[\widetilde{m}_1 - \widetilde{m}_2] + \frac{1}{\Delta_1'}[AH(1-\theta) + A_2H\ell + A_2B_1(1-\theta)] \\ & [\rho_2 - \rho_1] + \frac{1}{\Delta_1'}[A_2B_1(1-\theta) - A_2H\ell]\,[\rho_2 - \rho_1] \end{aligned} \quad (A.III.4)$$

where

$$\Delta_1' = [AH^2 + 2A_2B_1H]\,[1-\ell] = [BH^2 + 2A_2B_2H]\,[1-\ell]$$

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Revista de Análisis Económico, Vol. 3, Nº 2, pp. 229-231 (Noviembre 1988)

RESUMENES EN ESPAÑOL

PROJECTING POLICY EFFECTS WITH STATISTICAL MODELS

CHRISTOPHER A. SIMS

Este artículo intenta discutir en forma breve sobre las fronteras del conocimiento en torno a modelamiento cuantitativo con fines predictivos y de análisis de políticas. Ello se hace a través de un resumen de algunos de los más recientes desarrollos en tres áreas: modelos de pronóstico de forma reducida, modelos teóricos que incluyen elementos de optimización dinámica e identificación de modelos. Como parte de este esfuerzo, el artículo plantea algunos indicios acerca de la dirección que está tomando la investigación en esta materia.

IMPLEMENTING BAYESIAN VECTOR AUTOREGRESSIONS

RICHARD M. TODD

El presente trabajo discute cómo el enfoque bayesiano puede ser usado para construir un tipo de modelo de pronóstico multivariado conocido como de autorregresiones vectoriales bayesianas (BVAR). Para ello, se centra la presentación en las proposiciones de Doan, Litterman y Sims (1984), acerca de la forma de estimar un modelo BVAR basado en una cierta familia de distribuciones probabilísticas apriorísticas, indexadas por un número relativamente pequeño de hiperparámetros. También se discute cómo se especifica un BVAR y la manera en que se puede establecer una base de datos apropiada para la aplicación de un BVAR. Para ilustrar este enfoque estadístico se recurre a un ejemplo de un modelo BVAR de cuatro variables.

A BVAR FORECASTING MODEL FOR THE CHILEAN ECONOMY

RICHARD M. TODD y FELIPE G. MORANDE

En este trabajo los autores aplican la metodología de especificación y estimación de un BVAR propuesta en Doan, Litterman y Sims (1984) –DLS– al caso de la economía chilena representada en un conjunto reducido de ocho variables macroeconómicas clave. A pesar de la brevedad de las series consideradas (mensuales desde 1976 hasta 1987) y de los significativos cambios de política económica ocurridos en el período, los resultados satisfacen al menos uno de los criterios de eficiencia propuestos por DLS. Para el futuro se debe explorar la posibilidad de alterar en algunos aspectos el método de DLS.